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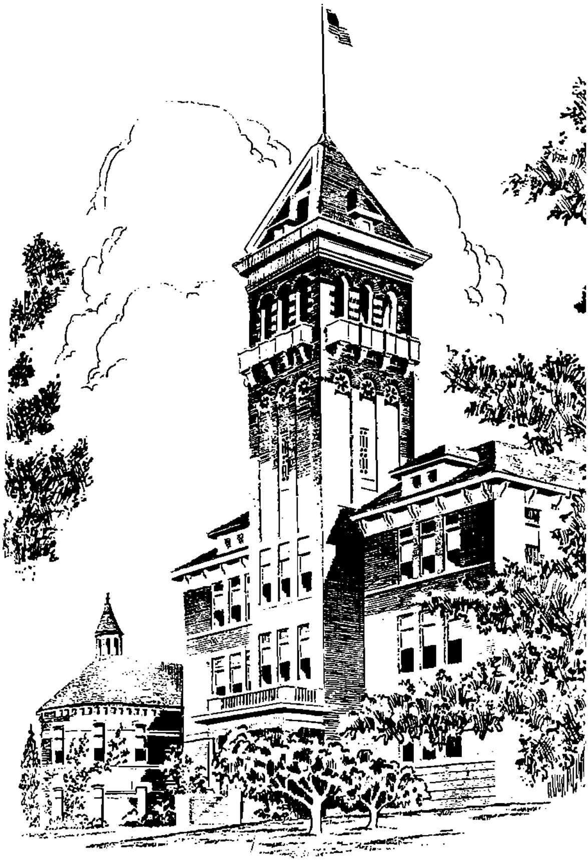

By Karl Harris and Vaughn E. Hansen

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Relative Productive Value of Land[1]

by

KARL HARRIS[2] and VAUGHN E. HANSEN[3]

Location, markets, hard surface roads and other transportation facilities, churches, taxes, schools and utilities are major factors in the monetary value of land, yet these things do not contribute to the land's productivity. In this bulletin the only factor considered in determining the agricultural value of land is its productive capacity.

The three major factors in the productive value of land are water, climate and soil.

These three factors are the principal ones in crop production. If any one of them is unfavorable to plant growth, it can inhibit or even prevent plant growth regardless of how favorable the other factors may be. Productive capacity of land is no better than that permitted by any one of the three factors. Even if two of the factors are favorable, the land will not produce above the capacity of the third.

This paper presents a system whereby the effect of soil, water and climate upon the productive capacity of land can be more clearly understood and more easily evaluated. Not only can the system be used to evaluate the productive capacity, but also to identify factors which may be lowering the value of the land and to evaluate their relative importance.

A number of factors that give value to land are rated. The values presented are average relative values which may need some modification before being applied in a specific locality.

The authors have presented a philosophy of land evaluation built around scientific facts. They fully expect the values presented to be

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[1]This bulletin is an expansion of ideas presented by the senior author in "Factors That Give Value To Land Or Basic Land Values," Bulletin 223, Agricultural Experiment Station, University of Arizona, July, 1949.

Some of the new material was developed while the authors were employed by the Hydrotechnic Corporation as Irrigation Engineer and Assistant Chief Engineer respectively in Angola, Portugese West Africa, surveying the agricultural potential of three river basins. Additional expansion and improvement has been made since the authors returned to their current activities.

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modified as further data become available — also, that additional graphical relationships will be developed for other quantities which have not been quantitatively evaluated in this presentation. This expansion and modification will come as the influence of these factors on agricultural value of land becomes clearer.

WATER

Agricultural water may come from one or more of five sources: (1) precipitation, (2) atmospheric water other than precipitation, (3) ground water, (4) flood water, and (5) irrigation water.

Failure to consider all five water sources and the proportion that each supplies to the total plant needs may mean a faulty design of an irrigation system. In some areas, one of the five sources may supply the major portion of the plant's needs; in other areas, two or even all five will contribute appreciable amounts to the water supply.

Precipitation

To be of greatest benefit, precipitation should have the following characteristics:

(1) Amounts should be sufficient to replace moisture depleted from the root zone.

(2) Frequency should be adequate to replenish the soil moisture before the plant suffers for lack of moisture.

(3) Intensity should be low enough that it can be absorbed by the soil.

In few locations will precipitation fulfill all of the above requirements at all times so as to produce maximum yields. The failure of precipitation to fill these requirements is resulting in increasing amounts of irrigation even in more humid areas.

Atmospheric Water Other Than Precipitation

In some parts of the world the contribution of atmospheric water in forms other than precipitation is significant. The atmospheric conditions which generally prevail to make this source of water significant are: (1) considerable dew formation, (2) fog and clouds, and (3) high humidity.

These atmospheric conditions reduce the plant's water needs by reducing the forces causing water to transpire from the plant. Dew is especially effective in reducing the amount of water moving through the plant, and in some cases, dew is absorbed by the plant. Water which evaporates from the ground and foilage normally reduces by a like amount the water which would have been withdrawn from the soil by the plant. Hence, the contribution of atmospheric moisture, in forms other than precipitation, should not be overlooked when considering the need for additional water for agricultural production.

Ground Water

Ground water is water beneath the soil surface where voids in the soil are substantially filled with water. Upward movement of ground water by capillarity from the water table into the root zone can be a major source of water for plant growth.

To be most effective, ground water should be near but below the major root zone. In this location, normal capillary rise will provide a major portion of the plant's water needs without seriously restricting growth. If ground water is within the normal root zone, it definitely restricts plant growth. If the ground water is too near the surface, the land's ability to economically produce most crops becomes almost nil. However, a water table within the lower portion of the root zone may supply sufficiently more water and thereby reduce the cost of irrigation to more than offset the loss of production. The optimum depth of the water table is that depth which gives the maximum economic return.

Flood Water

Flood water is similar in some respects to irrigation water, but it is not supplied by man. As the flood passes over the surface of the land, water is absorbed by the soil and stored for subsequent use by plants. In some regions, agricultural production is wholly dependent upon flood water.

Irrigation Water

Irrigation water is applied to the land to supplement the other four sources of water. In many areas more than 90 per cent of the plant's needs must be supplied by irrigation.

Quality of Irrigation Water

The quality of irrigation water has great influence on crop production, and consequently on productive value of land.

Reduction in yields of up to 25 percent may occur before it is realized that the salt content of the irrigation water is the cause. Figure 1 shows the relative value of land when irrigated with different amounts of soluble salts.

The more saline the irrigation water, the more frequently and the more abundantly must the land be irrigated. It is necessary to keep displacing the soil water downward to avoid high salt concentrations in the root zone. The amount of leaching of the root-zone soils—the amount of soil drainage—should be increased in proportion to the amount of salt in the water.

The saltier (or the more saline) the water, the fewer the crops that can be grown successfully. When using water with high salt content, a farmer must select salt-tolerant crops, adjust seedbed preparation and seeding practices to avoid salt accumulation in the seedbed, and irrigate with sufficient water to leach out excess salts. In addition, use of water high in salt content requires more uniform distribution of the irrigation water.

In attempting to classify water, probably too much attention has been placed upon the question, "How good is this water?" rather than, "What can be done with this water?" Probably too much attention has been given to the "toxic limits" of salt concentration and sodium percentage, and not enough emphasis upon the selection of suitable crops and adjustment of tillage and irrigation practices to the water available.

Utilization of the saltier waters involves restrictions, not necessarily prohibitions. Use of salty water on all soils is not recommended, but before water is pronounced unsuitable, management factors should be considered.

Material carried in suspension may be either beneficial or harmful, depending on the amount and kind of material. Eroded soil of good quality, carrying considerable organic matter, would be beneficial, but most types of industrial wastes and some types of eroded clay are harmful.

WATER AND CLIMATE

Regardless of how perfect are soil and water, without favorable climate, crop production is handicapped. The following climatic factors have direct influence on production: (1) length of growing period, (2) hours of daylight, (3) temperatures, (4) relative humidity, and (5) wind movement. No satisfactory method has yet been devised to describe the integrated effect of climate upon the productive capacity of the land.

The length of growing period is reasonably capable of description and will be outlined in the following section. Even though hours of daylight, temperatures, relative humidity, and wind movement can be measured, it is extremely difficult to quantitatively relate them to productive capacity. The most meaningful relationship has been obtained by correlating these climatic factors with water requirements and then relating water requirements to production.

The following section will first consider the length of the growing season. Afterward the integrated effect of daylight, temperature, humidity, and wind movement will be considered indirectly through its influence upon the water needed for crop production.

Length of Growing Period

The longer the growing period the greater the productivity of the land. If there is no frost during the year, many more combinations of crops can be grown and considerably more food and fiber can be produced on the same land than if the season were just long enough to grow grain.

If the season is long enough to grow cotton, it will be long enough to produce a great variety of crops. Two crops can often be grown and crops like alfalfa will produce high yields.

If the season is long enough to produce corn, it will also be possible to grow any of the grains and to obtain a fair yield of alfalfa.

If the season is just long enough to produce a crop of grain or potatoes, more acres are required to produce a given amount of food.

Such factors as daylight hours, temperatures, wind movement and relative humidity all have an influence on plant growth. But within certain limits, productive capacity of land is in proportion to length of growing period. Figure 2 shows the rating of soils as affected by the length of growing period.

Water Needed

Evaluation of water needs and climatic conditions can be made by determining the total water required during a year and by considering variations in the need during the growing season. Those periods in which climatic conditions are not favorable to growth will be evident. Such an analysis will indicate which crops can be grown and when they should be planted and harvested.

When the water needed is determined, it should be based upon the maximum water that would be used by any normal agricultural crop. This quantity, often referred to as potential consumptive use, can best be indexed by climatic factors.

Water Supply

The five possible sources of water outlined in an earlier section can be evaluated to determine the water supply. The amount of water that must be supplied by irrigation is the difference between the water needed and the water available from the other four sources.

Relative productive value of land depends upon the degree to which the available water will supply the crop's needs. The nature of this relationship is shown in Figure 3.

Power Requirements for Irrigation Water

Power which must be expended to supply needed irrigation water is of basic concern when evaluating the influence of water on relative agricultural value of land. The power requirement depends upon two factors: (1) the quantity to be supplied, and (2) the necessary lift. The simplest expression for power would be to multiply the quantity of water needed by the equivalent height to which water must be pumped. Thus an area which requires the same amount of water as another, but which as a result of its high position above the water supply requires more power, is worth less than an area which does not require as much power to supply the needed irrigation water, other conditions being the same.

Power can be expended in transporting water horizontally as well as lifting water vertically. Perhaps a feasible approach to evaluating the element of power where different methods of delivering water are involved would be to consider the relative cost of water. Relative cost reflects power requirement as well as other basic cost elements involved in supplying water to the land. Figure 4 shows the relationship between relative cost of water and relative productive value of land.

SOILS

Soils differ greatly in their productive capacity and thus in their agricultural value. This is due primarily to differences in the following features: (1) texture, (2) structure, (3) chemical composition and parent material, (4) depth, (5) slope of land, and (6) drainage hazard due to location.

To a large measure, these factors control the productive value of soil. To a large degree, they determine the extent of the root zone. They also indicate hazards as to tillage, erosion, cropping and water application.

Productive value of any soil is decreased in direct proportion to limitations inherent in the soil. The more the soil is limited as to the crops that can be grown and the methods of tillage or water application that can be used, the less is its productive value.

Texture of Soils

The size of the particles making up a soil determines its texture. These particles range in size from fine gravel to clay. Particles larger than 1.00 mm in diameter are gravel, particles from 0.05 to 1.00 mm are sand, particles from 0.002 to 0.05 mm are silt, and smaller than 0.002 mm are clay. Most soils contain a mixture of sand, silt and clay. If the sand particles dominate, the soil is called sand. If the clay particles dominate, it is called clay. Silts fall between the clay and sands. Loams are medium textured soils having about equal amounts of clay, silt and sand particles.

Surface soil is that which may be modified by tillage, and subsoil is that below this depth. The depth to which soils are modified by tillage varies in different localities. In areas where vegetables or sugar beets are harvested under wet conditions, soil compaction to a depth of 22 inches is not uncommon. Heavy machinery may also compact the soil to 22 inches. However, in most farm operations, the soil is not compacted below a depth of one foot.

Textural Properties of Surface and Subsurface Soils

Texture influences productive value in many ways. A number of soil properties are directly related to the texture. All seven of the following properties are related to the surface soil while only the first, second, and fifth are related to the subsurface soil: (1) available water to plants, (2) permeability to water, air and roots, (3) water intake rate, (4) tillage hazard, (5) stored plant nutrients, (6) power requirement for tillage, and (7) erodibility.

Importance of the above properties will vary in different areas. Regardless of specific conditions which prevail, however, each is a factor in crop production.

Available Water to Plants

The ability of soils to store and release water to plants varies considerably. Some clays may store and supply to the plant approximately three inches per foot of soil; some sands less than one inch per foot of soil. It is water-holding capacity that determines the amount of water that may be stored in soil to take care of water needs of plants between rains or irrigations.

Normally, clays will store in excess of two inches per foot, clay loams about two inches, loams a little less than two inches, and sands about an inch. Although clays hold the most water, this water is held so tightly by the soil that when plants are making rapid growth, the water is not as readily available as in loam soils. Considering the amount of water that different soils will hold and the way this water is released to plants, clay loam soils are probably the most desirable; loam soils probably the next most desirable; then clays and finally sands are least desirable because of lower water-holding capacity.

Permeability to Air, Water, and Roots

The ease with which air, water and roots move through the soil is an important factor in determining the rate of growth of young plants and is, therefore, an important factor in crop production. Clay soils, followed by clay loams, offer the most resistance to movement of air, water or roots because of extremely small pore spaces. It is very probable that loams are the most desirable soils in regard to permeability of air, water and roots, followed by sands, clay loams and then clays. Excessive permeability of sands is a slight disadvantage.

Water Intake Rates

Maintaining favorable intake rates is one of the major problems of crop production. Intake rate can change with each operation made on the soil. It is not uncommon to find a coarse sandy loam soil which is handled poorly having a slower intake rate than a clay soil handled properly. Sands normally have the most unsatisfactory intake rate because water enters the soil very rapidly. Under these conditions, special methods of irrigation must be used to get a uniform application of water without over-irrigating some portions of the field. On the other hand, most clays are so tight that it is difficult to get water into them. The sands have too rapid an intake and clays too slow. With normal handling, loams have the most satisfactory intake rate, then clay loams, followed by clays, with sands being least desirable.

Tillage Hazard

Tillage practices have tremendous influence on soils. Tillage breaks down the structure of the surface soil, reducing the movement of water, air and roots. Tillage has a greater detrimental effect on soils having low water stability.

Under average conditions, tillage hazards vary with soil texture. Sands are most desirable, followed by loams, then clay loams. Clays have the greatest tillage hazards.

Stored Plant Nutrients

Under normal conditions, the natural fertility varies with the size of the soil particles. Clays have the most natural fertility, followed by clay loams and loams. Sands have the least natural fertility.

Power Requirements

The influence of soil texture on the power required for tillage is difficult to evaluate. In areas of complete mechanization or where the individual land holdings are large, power requirements are of less significance than where land holdings are small. The smaller the operating unit, the more difficult it becomes to economically justify heavy equipment. Even if the heavy equipment is available, its use will always cost more on clay soils than it would on sandy soils. Sands have the lowest power requirements, with loams next. Clay loams and clays have the greatest power requirements.

Erodibility

Erodibility of soil to water becomes increasingly important as slope increases. On flat lands the hazard of erosion from water is not serious. Erodibility becomes more important when row crops are grown than when grass, grain or alfalfa is the chief crop. In areas of intense rainfall, erosion is a hazard even on moderate slopes. Silts and fine sands are most easily eroded; clays the least susceptible to erosion.

Rating Textural Properties of Soils

In varying degree, all soils are subject to hazard resulting from normal cropping, tillage, and irrigation. For example, erosion may result from a heavy rain, or soil structure may be partially destroyed by the necessity of harvesting a crop under wet conditions.

These hazards which always exist affect productive capacity of soil even though excellent management and perhaps good fortune may produce satisfactory production. Nevertheless, those same hazards and limitations do reduce production obtained from average management. The relative effect of these hazards upon production needs to be evaluated in a quantitative manner. Table 1 represents such an evaluation.

In table 1 seven factors are considered in the surface soil and only three in the subsurface. Each factor is given equal importance. To obtain the rating for each textural class, all hazards (rated from 1 to 10) are added. For surface soil, the average hazard was doubled and subtracted from 100 to get the rating. For subsurface soil, the average hazard was also doubled and subtracted from 100. The average hazard was doubled to obtain the desired scale. In a particular area it may be necessary to modify the scale or to give other than equal weight to each hazard.

The overall rating of soil is obtained by multiplying the ratings of the surface and subsurface soils. Table 2 is developed by multiplying combinations of the four textural classes. The result is sixteen combinations which include all possible groupings of surface and subsurface textures.

It is recognized, of course, that most soils, especially alluvial deposits, contain more than one texture in the surface and subsurface soil. However, the textural value to be used when referring to table 1 or 2 is the predominant or controlling textural characteristic of the profile. By so grouping and presenting the various combinations of texture, it is possible to see a given profile's rating and distinguishing characteristics in comparison to other profiles.

Unless logs of alluvial profiles are reduced to a characteristic texture, it is almost a hopeless task to characterize the agricultural properties. Since a soil profile behaves as a unit, the characteristic texture can and should be used to identify the soil.

Structure of Soils

Structure is an important factor in productive capacity of soils. Since soil structure can be modified readily by tillage and cropping systems, it is not a fixed soil characteristic. When structure is being evaluated, only the more general aspects—those which have the strongest tendency to remain unaffected by tillage and management—should be considered.

In a given area, structure may be important in two aspects: First, in the general distinctive structural characteristics of a given type of soil; second, the effect upon stability of structure due to environmental conditions of climate and water. Because of environmental conditions, some soils of the same texture will have an inherently more stable structure than others under similar management.

Chemical Composition of Soil

Chemical composition has great influence on productive capacity of soil. This may vary with the material from which the soil was formed and with age, climate, drainage, micro-organisms, and with the quality of water used for irrigation. In irrigated areas, the chief interest in the chemistry of soil is salt content and fertilizer requirements. Since these can be modified by drainage and leaching and by the addition of fertilizers, the chemistry of soil will not be considered in this bulletin as a basic or as a fixed characteristic property. Under some conditions, however, the type of clay mineral and the resulting soil properties will need to be considered.

Depth of Soil

Depth of soil has great influence on relative productive value. Normally the roots of a plant will increase during the active growth of the plant as long as they encounter favorable environment in the soil. Conditions necessary for a favorable environment are: (1) readily available moisture, (2) adequate air in soil, (3) favorable soil temperatures, (4) plant food, and (5) non-excessive amounts of toxic materials.

Plants that are able to develop a deep root system make better growth than plants with a restricted root system. Deep soil has greater water and greater nutrient storage capacity than shallow soil. The relative benefits from deep soils are not the same for all areas. The following factors affect the relative value: (1) climate, (2) crops grown in area, (3) length of growing period, and (4) economic aspects of the region.

Climatic Effect on Root Depth

Climate is a principal factor determining the importance of root zone depth. The crops grown, the length of growing period, and the economic aspects are important factors, but they are generally dependent upon and have been determined by climate.

The climatic characteristic which determines the value of deep soil to the greatest degree is the peak daily consumptive use of water by the crop during the year. Climatological factors such as temperature, wind movement and relative humidity have great influence on the peak consumptive use of water. When the peak demand for water is 0.40 inch per day, a restricted root system cannot normally supply the needed water, and the plant therefore does not make as rapid a growth as it would with a deeper root system.

Consumptive use of water by plants can be used to represent the integrated result of existing climatic factors affecting water use. Figure 5 shows relative value of land with a normal cropping system for various depths of soil as influenced by consumptive use of water by the crop.

Surface Configuration of Land

The three factors of slope, topography, and drainage hazard due to location should be considered as a unit because they collectively describe physical features of the land surface having direct bearing upon productive value.

In this bulletin conditions that can be changed by the expenditure of labor or money have not been considered as a part of basic productive capacity of land. With this interpretation placed on the production factors, slopes that may be reduced by practical leveling methods will not be considered, nor will rough land be evaluated that may be smoothed by leveling methods. However, degree of undulation of the surface is important and should be combined with the following evaluation of slope.

Soils of the same textural class differ greatly in the effect of slope on water intake and erosion. In some areas, irrigation water may run down slopes of over five per cent without serious erosion and at the same time maintain a good intake rate. In other areas running water down slopes of only one per cent will result in serious erosion and the water intake rate will be greatly reduced.

In areas where heavy sustained rains occur, flatter slopes may not be desirable even though water intake and erosion are less than on steeper slopes. Frequent rains on level land may cause serious damage to crops because of poor aeration. Sufficient slope to insure good surface drainage is desirable in such areas.

Hence, the relationship between slope and agricultural land value is governed by relative importance of surface drainage, erosion and water intake. Curves illustrating this interaction are presented in Figure 6. Values for a particular area will lie somewhere within the shaded area, depending upon relative importance of the factors indicated.

Other factors which also have considerable influence upon effect of slope on productive agricultural value are: (1) crops grown, (2) silt content, (3) stability of soil aggregates, (4) intensity and duration of rainfall, and (5) method and manner of irrigation.

Drainage Hazard Due to Location

Two pieces of land can have the same slope and topography, yet one might have less productive value due to its drainage hazard. The drainage problem will be much more serious if land is so located that it will receive surface and subsurface drainage from surrounding areas. Frequently, drainage from surrounding areas does not become an important factor until surrounding areas are irrigated.

Lower lands may have a drainage problem prior to irrigation if more water enters the soil than is required for consumptive use. When irrigation water is applied to land, often more water enters the soil on some portion of the irrigated area than is required for consumptive use. The excess water is either drained off, if surface and subsurface conditions are favorable, or if conditions are not favorable, contributes to a rising water table. Whenever a water table rises within the normal root-zone depth, effective rooting depth is decreased and productive capacity of land is reduced.

A water table that fluctuates is usually more serious than a water table that is consistently high. Some crops will adjust to a consistently high water table; however, when the water table lowers, the roots will extend into the de-watered soil; when the water table rises again, most plants will die from lack of oxygen before an adjustment can be made to the root's changing environmental conditions.

Subsurface soil conditions also are important in evaluating drainage hazard. Strips of less permeable subsoil may cause subsurface drainage water moving in from an adjacent area to be forced near the surface. Changes in permeability and thickness of subsurface strata are frequent causes of drainage problems.

When relative productive values of land are being determined, drainage hazard due to location and due to subsurface conditions cannot be neglected.

EXAMPLE OF RELATIVE LAND VALUES

Productive capacity of any land is no better than that of the weakest factor: for example, regardless of how favorable are soil and available water, land will not produce above the capacity of the climate. This is true of all three factors of soil, water and climate; they are all of equal importance and the land's productivity is limited by the weakest of the three.

To illustrate this concept, an anonymous but existing valley typical of many valleys will be cited. The valley was settled nearly 100 years ago but has never been very productive agriculturally. Farmers have made a living in the valley, but they have not grown rich and many have gone broke. Today the majority of the valley is pasture lands. The bulk of the area has relatively low productive value. Why is this so?

Some men have argued that drainage is the only necessary key to turning the valley into top production. Some men have had the courage to put in drains, and some have gone broke doing so. Some state that the wrong drainage was used, and so the debate continues.

Actually, several factors are responsible for the low production in this valley. Following is a list of some of the adverse factors, with the relative productive value based upon preceding sections of this bulletin:

Hazard	Relative Productive Value of the Land
(1) Hazard due to texture of surface soil being clay	88%
(2) Hazard due to texture of subsurface soil being clay	91%
(3) Length of growing season	70%
(4) Drainage hazard due to location	91%
Resultant relative production value (81 x 91 x 70 x 91) =	51%

The resultant value is the product of the component values since each factor is limiting and the resultant is no better than the poorest value. The above figures show more clearly than many words that drainage is important. But even if drainage were corrected (in this case the cost may be $75 per acre) the relative productive value would only be increased to 56 percent. Is the 6 percent increase sufficient to pay for the cost of drainage. The farmer who does not recognize the management hazard due to the presence of clay in both the surface and subsurface soil may still not have a profitable farm even after drainage. Length of growing season cannot be modified, but proper management will materially reduce the hazard due to the clay. Hence, a farmer using the techniques of managing clay soils and having installed good drainage may have a modified relative productive value as follows:

Hazard	Relative Productive Value of the Land
(1) Hazard due to texture of surface soil being clay	96%
(2) Hazard due to texture of subsoil being clay	98%
(3) Length of growing season	70%
(4) Drainage hazard due to location	97%
Resultant relative productive value	64%

With this better management, the farmer can probably make a reasonably good living. The method here presented of determining land values permits an evaluation of the actual benefit to be gained from corrective measures.

The relative values should be considered as first approximations. Consider what adjustments in relative productive value may be necessary to evaluate a particular area. Further correlation to economics for agricultural areas will also strengthen and extend the utility of the method.

When there are limitations which greatly reduce productive capacity, the individual units must be larger if the same standard of living is to be maintained. The following section outlines this concept.

Examples of the Use of Basic Land Values

The relative size of units can be illustrated with the material within this bulletin. Consider 100 acres where soils are deep, good water is available, and a 365-day growing season exists. Compare this to an area having 150-day growing season and average daily energy available for growth. Figure 2 gives a relative productive value of the land under this condition of 50 percent. If no other conditions were limiting, it would take 100 divided by 0.5 or 200 acres to product the same standard of living as 100 acres would produce without the restricted growing season.

Another area also has a 150-day growing season with average daily consumptive use of water, but the depth of soil is only 3 feet. Figure 5 shows a relative productive value of approximately 75 percent. Hence, with no other restrictions in the valley, it would take 100 divided by the product 0.5 times 0.75 or 270 acres, approximately, compared with the previously outlined conditions.

A final example could be a high mountain valley where the growing season is only 75 days with low daily consumptive use. From Figure 2, it is seen that the relative productive value of the land would be only 12 percent. Hence, it would require 100 divided by 0.12 or 825 acres to compete with the other areas outlined.

It can be seen that the various factors which give value to land are real and logical. They can be approximated in a quantitative manner and will therefore be valuable in better understanding the factors influencing the economy of farming.

MANAGEMENT GUIDES

In addition to their value as guides to land evaluation, the seven factors related to soil texture are also very useful as a guide to management of soils. The agricultural characteristics of the major textural classes of soil have been outlined in table 3 in terms of these seven properties for various combinations of surface and subsurface soils. By such a presentation, the change in a given characteristic of soil can be observed for different soil textures. Such an outline can be very useful in understanding the influence of texture on the various agricultural characteristics.

Management Practices Recommended for the Major Textural Classes of Soil

The agricultural characteristics outlined in table 3 have been interpreted in terms of management practices in table 4. Hence, if a clay surface soil is underlain by a sand, the influence can be seen in this combination of conditions in terms of irrigation, drainage, cropping, fertilizer, tillage, machinery, and land preparation.

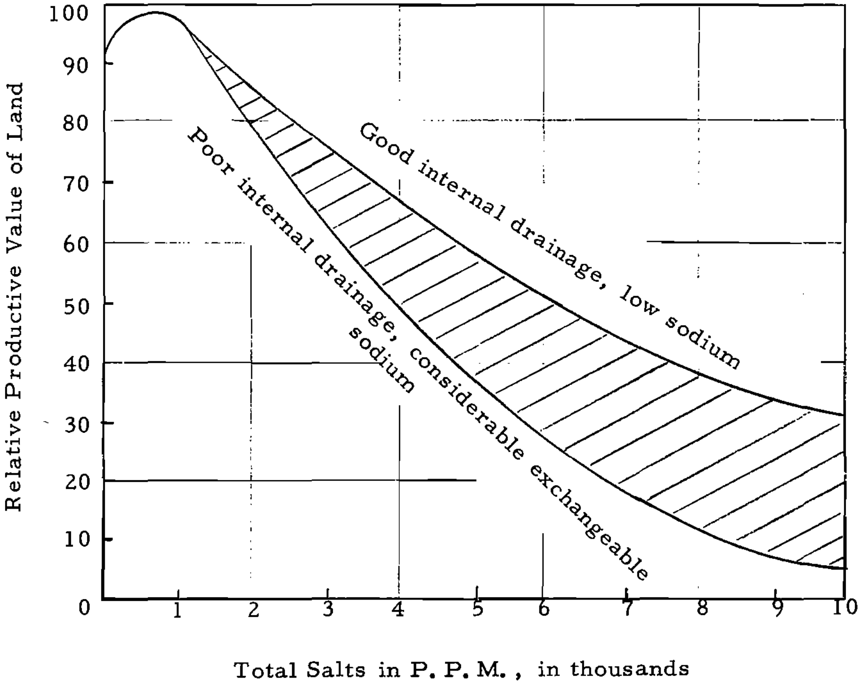

Figure 1. Effect of salt in water on relative productive value of land.

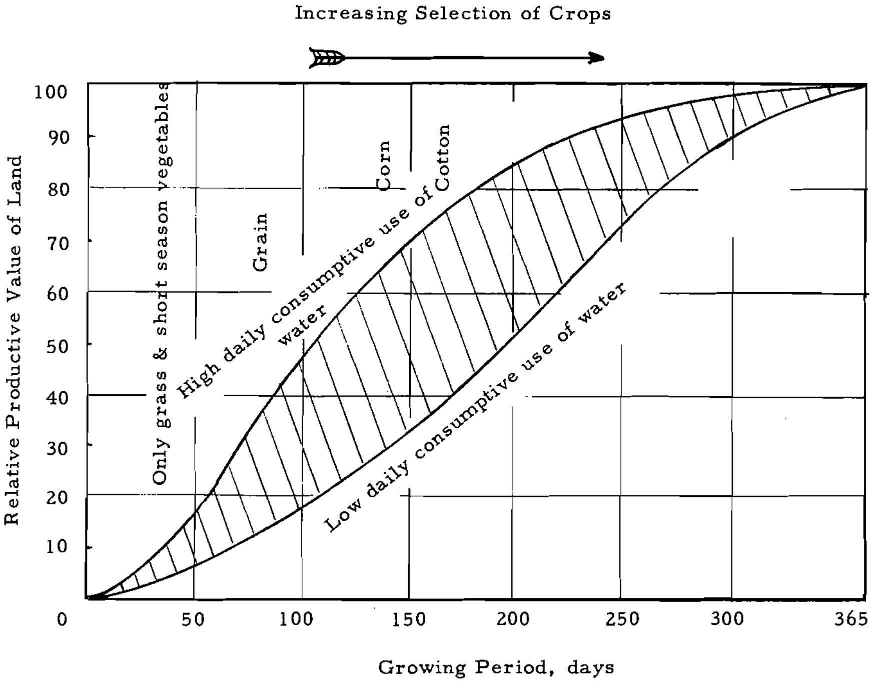

Figure 2. Influence of growing period on relative productive value of land.

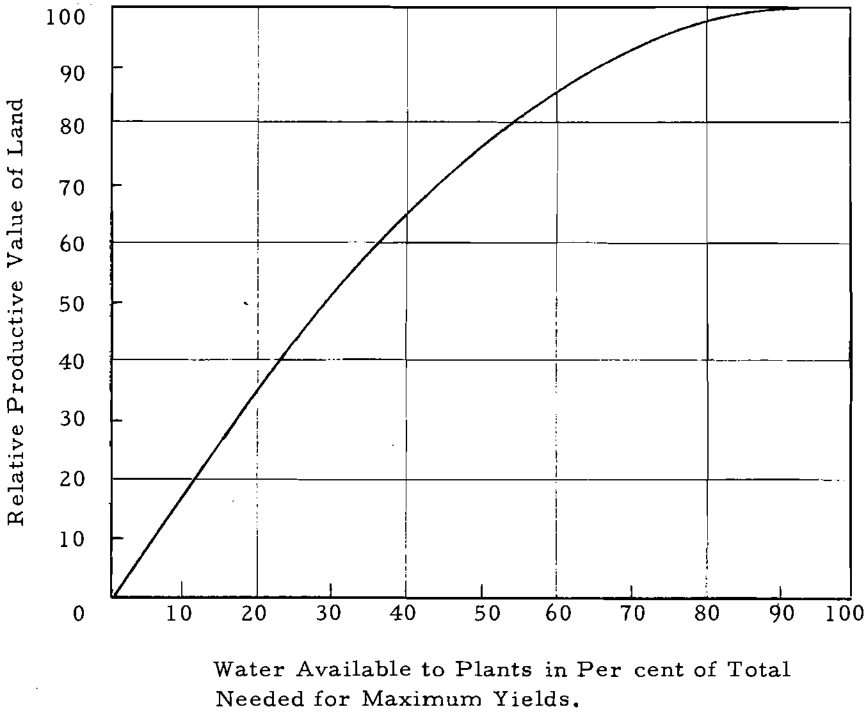

Figure 3. Influence of the amount of water that is available to the plants on the relative productive value of land.

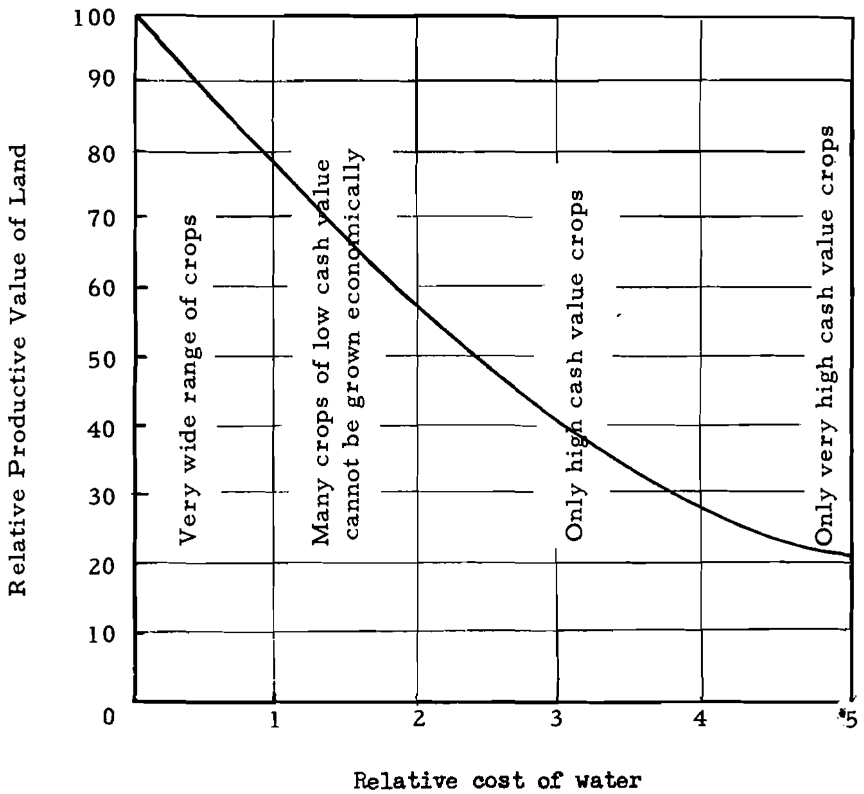

Figure 4. Relation between relative cost of water and the relative productive value of land
value of land

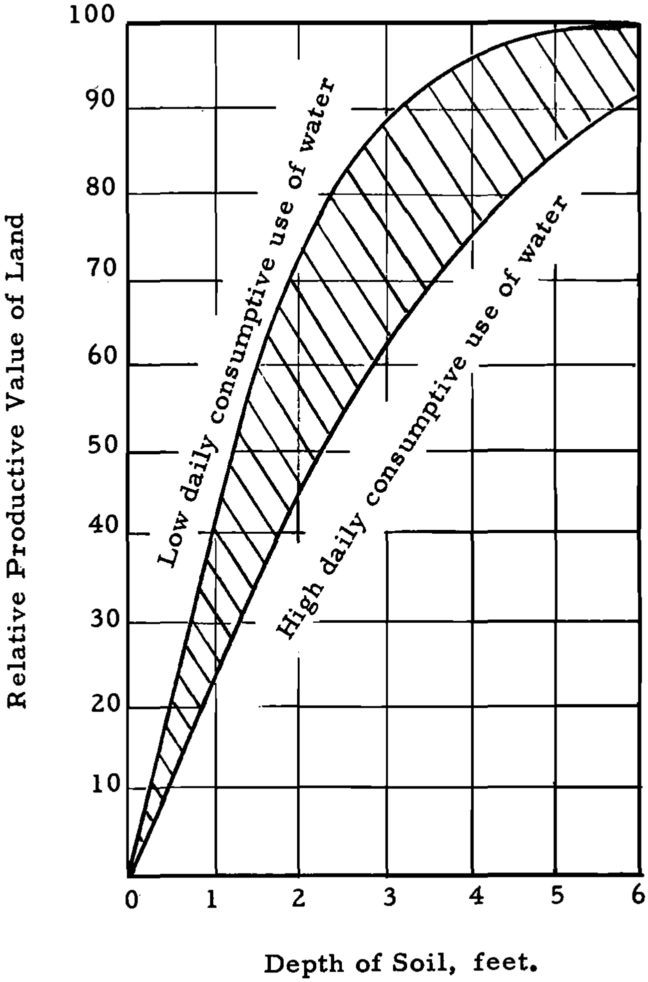

Figure 5. Effect of depth of soil above impervious material, permanent water table, or coarse gravel on relative productive value of land.

Note: Position of the curve within shaded zone depends upon relative importance of drainage, erosion, intake, and stability of the soil structure.

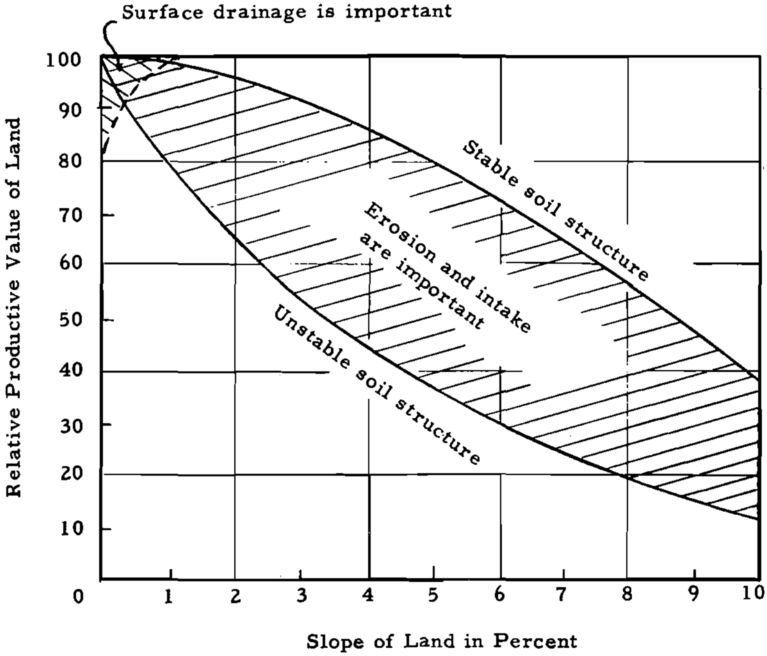

Figure 6. Effect of slope on the relative productive value of land.

Table 1. Relative rating of properties of soil due to texture

Hazards due to texture	Major Textural Classes of Soil			
	Loam	Clay Loam	Clay	Sand
Surface Soil				
1. Water available to plants	1	0	3	10
2. Permeability to air, water, and roots	0	4	10	2
3. Water intake rate	0	3	8	10
4. Tillage hazards	3	5	10	2
5. Natural fertility	3	2	1	10
6. Power requirements	2	4	7	0
7. Erosion hazard	5	3	2	7
Total Hazards	14	21	41	41
Average Hazard	2	3	6	6
Rating (100 - 2 x average hazard)	96	94	88	88
Subsurface Soil				
1. Water available to plants	1	0	3	10
2. Permeability to air, water, and roots	0	4	10	2
3. Natural fertility	3	2	1	10
Total Hazards	4	6	14	22
Average Hazard	1.3	2	4.7	7.3
Rating (100 - 2 x average hazard)	97	96	91	85

Table 2. Relative productive rating of major soil textural classes

SURFACE SOIL

		Loam	Clay Loam	Clay	Sand
		96	94	88	88
Loam	97	93	91	85	85
Clay Loam	96	92	90	84	84
Clay	91	87	86	80	80
Sand	85	82	80	75	75

SUBSURFACE

Decreasing Value

Decreasing Value

SURFACE SOILS

SUBSURFACE SOILS	LOAMS	CLAY LOAMS	CLAYS	SANDS
LOAMS	Available Water to Plants – High in both surface and subsurface soil. Permeability to Water, Air and Roots – Very good in both surface and subsurface soil. Water Intake Rate – Good. Tillage Hazard – Moderate. Stored Plant Nutrients – Medium in surface and subsurface soil. Power Requirement – Moderate. Erodibility – High.	Available Water to Plants – Very high in surface soil, high in subsoil. Permeability ot Water, Air and Roots – Medium in surface soil, very good in subsoil. Water Intake Rate – Medium. Tillage Hazard – Serious. Stored Plant Nutrients – High in surface soil, medium in subsoil. Power Requirement – Heavy. Light tractors and machinery not adequate. Erodibility – Medium.	Available Water to Plants – Medium in surface, high in subsoil. Permeability to Water, Air and Roots – Very poor in surface soil, very good in subsoil. Water Intake Rate – Very poor. Tillage Hazard – Very serious. Stored Plant Nutrients – Very high in surface soil, medium in subsoil. Power Requirement – Very heavy. Heavy tractors and equipment needed. Erodibility – Low.	Available Water to Plants – Very low in surface soil, high in subsoil. Permeability to Water, Air and Roots – Very high and perhaps excessive in surface soil, very good in subsoil. Water Intake Rate – Excessive. Tillage Hazard – Small. Stored Plant Nutrients – Very low in surface soil, medium in subsoil. Power Requirement – Light. Light tractors and equipment adequate. Erodibility – Very high.
CLAY LOAMS	Available Water to Plants – High in surface soil, very high in subsoil. Permeability to Water, Air and Roots – Very good in surface soil, medium in subsoil. Water Intake Rate – Good. Tillage Hazard – Moderate. Stored Plant Nutrients – Medium in surface soil, high in subsoil. Power Requirement – Moderate. Erodibility – High.	Available Water to Plants – Very high in both surface and subsurface soil. Permeability ot Water, Air and Roots – Medium in both surface and subsurface soil. Water Intake Rate – Medium. Tillage Hazard – Serious. Stored Plant Nutrients – High in both surface and subsurface soil. Power Requirement – Heavy. Light tractors and machinery not adequate. Erodibility – Medium.	Available Water to Plants – Medium in surface soil, very high in subsoil. Permeability to Water, Air and Roots – Very poor in surface soil, medium in subsoil. Water Intake Rate – Very poor. Tillage Hazard – Very serious. Stored Plant Nutrients – Very high in surface soil, high in subsoil. Power Requirment – Very heavy. Heavy tractors and equipment needed. Erodibility – Low.	Available Water to Plants – Very low in surface soil, very high in subsoil. Permeability to Water, Air and Roots – Very high and perhaps excessive in surface soil, medium in subsoil. Water Intake Rate – Excessive. Tillage Hazard – Small. Stored Plant Nutrients – Very low in surface soil, high in subsoil. Power Requirement – Light. Light tractors and equipment adequate. Erodibility – Very high.
CLAYS	Available Water to Plants – High in surface soil, medium in subsoil. Permeability to Water, Air and Roots – Very good in surface soil, very poor in subsoil. Water Intake Rate – Good. Tillage Hazard – Moderate. Stored Plant Nutrients – Medium in surface soil, very high in subsoil. Power Requirement – Moderate. Erodibility – High.	Available Water to Plants – Very high in surface soil, medium in subsoil. Permeability to Water, Air and Roots – Medium in surface soil, very poor in subsoil. Water Intake Rate – Medium. Tillage Hazard – Serious. Stored Plant Nutrients – High in surface soil, very high in subsoil. Power Requirements – Heavy. Light tractors and machinery not adequate. Erodibility – Medium.	Available Water to Plants – Medium in both surface and subsurface soil. Permeability to Water, Air and Roots – Very poor in both surface and subsurface soil. Water Intake Rate – Very poor. Tillage Hazard – Very serious. Stored Plant Nutrients – Very high in surface and subsurface soil. Power Requirement – Very heavy. Heavy tractors and equipment needed. Erodibility – Low on alluvial soils.	Available Water to Plants – Very low in surface soil, medium in subsoil. Permeability to Water, Air and Roots – Very high and perhaps excessive in surface soil, very poor in subsoil. Water Intake Rate – Excessive. Tillage Hazard – Small. Stored Plant Nutrients – Very low in surface soil, very high in subsoil. Power Requirements – Light. Light tractors and equipment adequate. Erodibility – Very high.
SANDS	Available Water to Plants – High in surface soil, very low in subsoil. Permeability to Water, Air and Roots – Very good in surface soil, very high and perhaps excessive in subsoil. Water Intake Rate – Good. Tillage Hazard – Moderate. Stored Plant Nutrients – Medium in surface soil, very low in subsoil. Power Requirement – Moderate. Erodibility – High.	Available Water to Plants – Very high in surface soil, very low in subsoil. Permeability to Water, Air and Roots – Medium in surface soil, very high and perhaps excessive in subsoil. Water Intake Rate – Medium. Tillage Hazard – Serious. Stored Plant Nutrients – High in surface soil, very low in subsoil. Power Requirement – Heavy. Light tractors and machinery not adequate. Erodibility – Medium.	Available Water to Plants – Medium in surface soil, very low in subsoil. Permeability to Water, Air and Roots – Very poor in surface soil, very high and perhaps excessive in subsoil. Water Intake Rate – Very poor. Tillage Hazard – Very serious. Stored Plant Nutrients – Very high in surface soil, very low in subsoil. Power Requirement – Very heavy. Heavy tractors and equipment needed. Erodibility – Low.	Available Water to Plants – Very low in surface and subsurface soil. Permeability to Water, Air and Roots – Very high and perhaps excessive in both surface and subsurface soil. Water Intake Rate – Excessive. Tillage Hazard – Small. Stored Plant Nutrients – Very low in surface and subsurface soil. Power Requirement – Light. Light tractors and equipment adequate. Erodibility – Very high.

Stored Plant Nutrients – Medium in surface and subsurface soil. Power Requirement – Moderate. Erodibility – High.	Stored Plant Nutrients – High in surface soil, medium in subsoil. Power Requirement – Heavy. Light tractors and machinery not adequate. Erodibility – Medium.	Stored Plant Nutrients – Very high in surface soil, medium in subsoil. Power Requirement – Very heavy. Heavy tractors and equipment needed. Erodibility – Low.	Stored Plant Nutrients – Very low in surface soil, medium in subsoil. Power Requirement – Light. Light tractors and equipment adequate. Erodibility – Very high.
Available Water to Plants – High in surface soil, very high in subsoil. Permeability to Water, Air and Roots – Very good in surface soil, medium in subsoil. Water Intake Rate – Good.	Available Water to Plants – Very high in both surface and subsurface soil. Permeability ot Water, Air and Roots – Medium in both surface and subsurface soil.	Available Water to Plants – Medium in surface soil, very high in subsoil. Permeability to Water, Air and Roots – Very poor in surface soil, medium in subsoil.	Available Water to Plants – Very low in surface soil, very high in subsoil. Permeability to Water, Air and Roots – Very high and perhaps excessive in surface soil, medium in subsoil.

MANAGEMENT PRACTICES RECOMMENDED FOR MAJOR TEXTURAL CLASSES OF SOILS

Table 4

DECREASING AGRICULTURAL VALUES

SURFACE SOILS

SUBSURFACE SOILS	LOAMS	CLAY LOAMS	CLAYS	SANDS
LOAMS	**Irrigation** — Adaptable to any method. One out of three irrigations should store water below 15 in. for shallow or 30 in. for deep-rooted crops. **Drainage** — Excess water can be easily removed. **Cropping** — Adaptable to a wide range of crops and cropping systems. Legumes and fibrous rooted crops are needed to maintain good structure. **Fertilizer** — Apply fertilizers according to needs as determined by field trials. Avoid washing nitrogen out of surface soil. **Tillage** — Break soil below any compacted layer. Avoid excessive working of soil. Return all plant residues to surface soil. **Machinery** — Light tractors and equipment adequate. **Land Preparation** — Similarity of surface and subsurface soil permits extensive land leveling.	**Irrigation** — Adaptable to any method of irrigation. One out of three irrigations should store water below 15 in. depth for shallow or 30 in. for deep-rooted crops. **Drainage** — Subsoil allows freer movement of water than surface soils. Excess water in the soil can be easily removed. **Cropping** — Adaptable to a wide choice of crops and cropping systems. Legumes and fibrous rooted crops are needed to maintain good structure. **Fertilizer** — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials. **Tillage** — Break soil below any compacted layer. Allow air and water to condition soil. Keep plant residues on or near surface. **Machinery** — Medium size tractors and implements adequate. **Land Preparation** — Exposing subsurface loam by land leveling should be minimized.	**Irrigation** — Wide choice of methods but each must be designed for a slow intake rate. One out of three irrigations should store water below 15 in. for shallow or 25 in. for deep-rooted crops. **Drainage** — Good internal drainage. Excess water in subsoil can be easily removed. **Cropping** — Plant soil conditioning crops one-third of the time. Return as much plant residue to the soil as possible. **Fertilizer** — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials. Good crop rotation and tillage practices will reduce fertilizer needs. **Tillage** — Faulty tillage reduces water and air movement. Plow below compacted layer. Avoid pulverizing soil. Allow water and air to condition soil. Keep all possible plant residues on or near surface. **Machinery** — Heavy tractors and equipment needed. **Land Preparation** — Keep land leveling to minimum. Avoid exposing more permeable subsoil to reduce problem of obtaining uniform water distribution.	**Irrigation** — Method limited to sprinklers or relatively small basins because of high intake rate. One out of three or four irrigations should store water below 15 in. for shallow or 30 in. for deep-rooted crops. Frequent and light irrigations are necessary to maintain favorable fertility and moisture conditions in sand and to minimize excessive deep percolation and loss of nutrients. **Drainage** — Excess water can be easily removed from loam subsoil. **Cropping** — Adapted to wide choice of crops. Legumes are needed to maintain good structure. Return all possible plant residues to the soil. **Fertilizer** — Apply nitrogen fertilizer frequently in small quantities. Make first nitrogen fertilizer application after initial irrigation to avoid leaching from surface soil. **Tillage** — Avoid unnecessary working of the soil. Keep all possible plant residue on or near surface. **Machinery** — Very light tractors and implements adequate. **Land Preparation** — Avoid land leveling which would expose less permeable subsoil and make uniform distribution of irrigation water difficult.
CLAY LOAMS	**Irrigation** — Wide choice of methods. One out of three irrigations should store water below 15 in. for shallow or 25 in. for deep-rooted crops. **Drainage** — Subsoil drainage will not be a problem if surface drainage is adequate and if excessive applications of irrigation water are avoided. **Cropping** — Adapted to a wide choice of crops and cropping systems. Legumes and fibrous rooted crops are needed to maintain good structure. Return maximum amount of plant residue to the soil. **Fertilizer** — Apply fertilizer according to needs as determined by field trials. Avoid washing nitrogen out of surface soil. **Tillage** — Break soil below any compacted layer. Avoid pulverization of the soil. Return all plant residues to surface soil. **Machinery** — Light tractors and equipment adequate. **Land Preparation** — Avoid excessive leveling, which would expose subsoil and make tillage and application of irrigation water more difficult.	**Irrigation** — Wide choice of methods, but each must be designed for slow intake and percolation rates. One out of three irrigations should store water below 15 in. for shallow or 25 in. for deep-rooted crops. **Drainage** — With good land preparation, tillage, cropping and irrigation methods, internal drainage should be adequate. **Cropping** — Adaptable to a wide choice of crops and cropping systems. Legumes and fibrous rooted crops are needed to maintain good soil structure. Return all possible plant residues to the soil. **Fertilizer** — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials. **Tillage** — Break soil below any compacted layer. Allow air and water to condition soil. Keep plant residues on or near soil surface. **Machinery** — Medium to heavy tractors and equipment required. **Land Preparation** — Similarity of surface and subsurface soil permits extensive leveling.	**Irrigation** — Wide choice of methods, but each must be designed for a slow intake rate. One out of three irrigations should store water below 15 in. for shallow or 25 in. for deep-rooted crops. **Drainage** — Provide good surface drainage through good tillage and leveling and use drainage ditches as needed to prevent excess water accumulating in subsoil. Subsoil has fair drainage characteristics. **Cropping** — Plant soil conditioning crops one-third of the time. Maximum amount of plant residues should be returned to the soil. **Fertilizer** — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials. Good crop rotations and tillage practices will reduce fertilizer needs. **Tillage** — Faulty tillage restricts water and air movement. Plow below compacted layer. Avoid pulverization of the soil. Allow water and air to condition soil. Keep all possible plant residues on or near surface. **Machinery** — Heavy tractors and equipment required. **Land Preparation** — Keep land leveling to a minimum. Non-uniform surface soils make irrigation and tillage more difficult.	**Irrigation** — Method limited to sprinklers or relatively small basins because of high intake rate. Avoid perched water table. Light, frequent irrigations are advisable. One irrigation in four or five should penetrate deeper than 15 in. for shallow or 25 in. for deep-rooted crops. **Drainage** — No difficulty expected in removing excess water from clay-loam subsoil if good irrigation practices are allowed. **Cropping** — Adaptable to a wide choice of crops and cropping systems. Legumes are needed to maintain good soil structure. Return all possible plant residues to the soil. **Fertilizer** — Apply nitrogen fertilizer frequently in small quantities. Make first nitrogen fertilizer application after initial irrigation to avoid leaching from surface soil. **Tillage** — Avoid unnecessary working of the soil. Keep all possible plant residues on or near the surface. **Machinery** — Light tractors and equipment adequate. **Land Preparation** — Avoid exposing clay-loam subsoil which would make uniform water distribution and good tillage difficult.
CLAYS	**Irrigation** — Design irrigation system to insure even distribution of water laterally and vertically. Preplanting irrigation advisable. Avoid perched water table. One irrigation of four should store water below the 15 to 20 in. depth, depending upon the root zone. **Drainage** — As clay subsoil is difficult to drain, special drainage practices are needed for removing excess water from subsoil. Avoid exeess water entering subsoil. **Cropping** — Crops which will tolerate poor internal drainage are desirable. Legumes and fibrous rooted crops are needed to maintain good soil structure. Return all plant residuc to the soil. **Fertilizer** — Apply according to needs as determined by field trials. Avoid washing nitrogen out of surface soil. **Tillage** — Break soil below any compacted layer. Avoid pulverization of the soil. Return all plant residues to surface soil. **Machinery** — Light tractors and equipment are adequate. **Land Preparation** — Avoid exposing heavy clay subsoil which would make uniform water application and tillage more difficult.	**Irrigation** — Wide choice of methods. Chief problem is slow rate of water movement through subsoil. Preplanting irrigation is desirable. One irrigation in four should store water below the 15 to 20 in. depth. Do not give a heavy irrigation during a period of heavy rains other than the preplanting irrigation. **Drainage** — As clay subsoil is difficult to drain, avoid excess water in subsoil by good irrigation and good surface drainage practices. **Cropping** — Use cropping systems which will tolerate poor internal drainage. Legumes and fibrous rooted crops are needed to maintain good soil structure. Return all plant residue to the soil. **Fertilizer** — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials. **Tillage** — Break soil below any compacted layer. Allow air and water to condition soil. Keep plant residues on or near surface. **Machinery** — Medium to heavy tractors and equipment required. **Land Preparation** — Avoid exposing clay subsoil which would make uniform water application and tillage more difficult.	**Irrigation** — Methods must be designed for a low intake rate. A preplanting irrigation is advisable. One out of four irrigations should store moisture below the 15 to 20 in. depth. Special care should be given to the disposal of excess rain and irrigation water. **Drainage** — On the flatter slopes, surface and subsurface drainage is difficult. Surface water from steeper areas must be intercepted. **Cropping** — Plant soil conditioning crops one-third of the time. Return all plant residues to the soil. **Fertilizer** — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials. Good crop rotation and tillage practices will reduce fertilizer needs. **Tillage** — Faulty tillage restricts water and air movement. Plow below compacted layer. Avoid pulverizing soil. Allow water and air to condition soil. Keep all possible plant residues on or near surface. **Machinery** — Heavy tractors and equipment required. **Land Preparation** — Similarity of surface and subsurface soils permits extensive land leveling if needed, but fertility will be temporarily lowered.	**Irrigation** — Difficult to irrigate because of high intake rate and low water holding capacity of the sand, and the poor drainage characteristics of the clay subsoil. Sprinkler irrigation or other methods with a good water control are necessary. Light, frequent irrigations are advisable. Preplanting irrigation is very desirable. One out of five or six irrigations should store water below the 15 to 20 in. depth. **Drainage** — Clay subsoil present a difficult problem. Provide for removal of excess water that may accumulate during rainy months or from excessive irrigations. **Cropping** — Use cropping system which will tolerate poor internal drainage. Plant soil conditioning crops in rotation. Return all plant residues to soil. **Fertilizer** — Apply nitrogen fertilizer frequently in small quantities. Make first nitrogen fertilizer application after initial irrigation to avoid leaching from surface soil. **Tillage** — Avoid unnecessary working of the soil. Keep all possible plant residues on or near the surface. **Machinery** — Light tractors and equipment adequate. **Land Preparation** — Avoid exposing clay subsoil thus making uniform distribution of water and good tillage difficult.
SANDS	**Irrigation** — Wide choice of irrigation methods, but care must be taken to avoid leaching and excessive water loss from sandy subsoil. Light frequent applications with good distribution are desirable. **Drainage** — Adequate in surface soils, but may be excessive in sandy subsoil, which has a low water holding capacity. **Cropping** — Adapted to wide selection of crops and cropping systems. Deep rooted crops are excellent. Return crop residues to soil. **Fertilizer** — Apply according to needs as determined by field trials. Trials adequate and if excessive applications of irrigation water are avoided.	**Irrigation** — Wide choice of irrigation methods. Frequent light and uniform applications are desirable to avoid leaching and excess water loss from sandy subsoil. **Drainage** — Some surface drainage will be needed. Excellent drainage of subsoil. **Cropping** — Adapted to a wide range of crops and cropping systems. Legumes and fibrous rooted crops are needed to maintain good soil structure. Return all possible plant residues to the soil. **Fertilizer** — [illegible]	**Irrigation** — Irrigation will be difficult because of low intake rate and low water holding capacity of subsoil. Frequent irrigations will be necessary to maintain adequate subsoil moisture. Adaptable to most irrigation methods. **Drainage** — Surface drainage will be necessary. Good drainage in subsurface soils. **Cropping** — Adaptable to a wide choice of crops. Plant soil conditioning crops one-third of the time. Return all possible plant residues to the soil. **Fertilizer** — Faulty management may reduce nutrient availability. Apply [illegible]	**Irrigation** — Frequent light irrigations by sprinklers or in small basins are desirable in order to increase extent of root zone because of high intake rates and low water holding capacity. Once root zone is extended heavier applications will be needed. Cost of irrigation equipment and labor will be high. **Drainage** — Surface and subsurface soils easily drained. **Cropping** — Plant legumes and fibrous rooted crops frequently. Keep all plant residues on or near the surface. **Fertilizer** — [illegible]

| CLAY LOAMS | **Cropping** — Adapted to a wide choice of crops and cropping systems. Legumes and fibrous rooted crops are needed to maintain good strueture. Return maximum amount of plant residue to the soil.
Fertilizer — Apply fertilizer according to needs as determined by field trials. Avoid washing nitrogen out of surface soil.
Tillage — Break soil below any compacted layer. Avoid pulverization of the soil. Return all plant residues to surface soil.
Machinery — Light tractors and equipment adequate.
Land Preparation — Avoid excessive leveling, which would expose subsoil and make tillage and application of irrigation water more difficult. | methods, internal drainage should be adequate.
Cropping — Adaptable to a wide choice of crops and cropping systems Legumes and fibrous rooted crops are needed to maintain good soil structure. Return all possible plant residues to the soil.
Fertilizer — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials.
Tillage — Break soil below any compacted layer. Allow air and water to condition soil. Keep plant residues on or near soil surface.
Machinery — Medium to heavy tractors and equipment required.
Land Preparation — Similarity of surface and subsurface soil permits extensive leveling. | ing and use drainage ditches as needed to prevent excess water accumulating in subsoil. Subsoil has fair drainage characteristics.
Cropping — Plant soil conditioning crops one-third of the time. Maximum amount of plant residues should be returned to the soil.
Fertilizer — Faulty management may reduce nutrient availability. Apply fertilizers according to needs as determined by field trials. Good crop rotations and tillage practices will reduce fertilizer needs.
Tillage — Faulty tillage restricts water and air movement. Plow below compacted layer. Avoid pulverization of the soil. Allow water and air to condition soil. Keep all possible plant residues on or near surface.
Machinery — Heavy tractors and equipment required.
Land Preparation — Keep land leveling to a minimum. Non-uniform surface soils make irrigation and tillage more difficult. | **Drainage** — No difficulty expected in removing excess water from clay-loam subsoil if good irrigation practices are allowed.
Cropping — Adaptable to a wide choice of crops and cropping systems. Legumes are needed to maintain good soil structure. Return all possible plant residues to the soil.
Fertilizer — Apply nitrogen fertilizer frequently in small quantities. Make first nitrogen fertilizer application after initial irrigation to avoid leaching from surface soil.
Tillage — Avoid unnecessary working of the soil. Keep all possible plant residues on or near the surface.
Machinery — Light tractors and equipment adequate.
Land Preparation — Avoid exposing clay-loam subsoil which would make uniform water distribution and good tillage difficult. |
| | **Irrigation** — Design irrigation system to insure even distribution of water laterally and vertically. Preplanting irrigation advisable. Avoid perched water table. One irrigation of four should store water below the 15 to 20 in. depth, depending upon the root zone.
Drainage — As clay subsoil is difficult to drain, special drainage practices are needed for removing excess water from subsoil. Avoid exeess water | **Irrigation** — Wide choice of methods. Chief problem is slow rate of water movement through subsoil. Preplanting irrigation is desirable. One irrigation in four should store water below the 15 to 20 in. depth. Do not give a heavy irrigation during a period of heavy rains other than the preplanting irrigation.
Drainage — As clay subsoil is difficult to drain, avoid excess water in sub- | **Irrigation** — Methods must be designed for a low intake rate. A preplanting irrigation is advisable. One out of four irrigations should store moisture below the 15 to 20 in. depth. Special care should be given to the disposal of excess rain and irrigation water.
Drainage — On the flatter slopes, surface and subsurface drainage is difficult. Surface water from steeper areas must be intercepted. | **Irrigation** — Difficult to irrigate because of high intake rate and low water holding capacity of the sand, and the poor drainage characteristics of the clay subsoil. Sprinkler irrigation or other methods with a good water control are necessary. Light, frequent irrigations are advisable. Preplanting irrigation is very desirable. One out of five or six irrigations should store water below the 15 to 20 in. depth. |

SUBSURFACE SOILS

Table 4

DECREASING AGRICULTURAL